

The Drosophilidae of Taiwan: Genera *Amiota* (excluding subgenus *Phortica*) and *Leucophenga* (*Nankangomyia* subg. nov.)¹

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Jan Maca and Fei-Jann Lin (1993) The Drosophilidae of Taiwan: Genera *Amiota* (excluding subgenus *Phortica*) and *Leucophenga* (*Nankangomyia* subg. nov.). *Bull. Inst. Zool., Academia Sinica* 32(1): 1-11. Six species of *Amiota* (*Amiota*) (*A. (A.) furcata* Okada, *A. (A.) subfurcata* Okada, *A. (A.) dentata* Okada, *A. (A.) okinawana* Okada, *A. (A.) atomia* sp. nov., and *A. (A.) sacculipes* sp. nov.) from Taiwan are recorded. Of the subgenus *Apsiphortica* (previously known only from the type locality of *A. (A.) lini* Okada), additional data on this species was collected at a new location. We discuss a) a new species belonging to *Leucophenga* (*Nankangomyia*) (including *academica* sp. nov. and b) two species previously classified in the subgenus *Amiota* their affinities to related groups of Steganinae.

Key words: *Amiota*, *Leucophenga*, *Nankangomyia* subg. nov., *A. atomia* sp. nov., *A. sacculipes* sp. nov., *L. academica* sp. nov.

In spite of the great number of species of the subgenus *Amiota* s. str. occurring in the Eastern part of the Palearctic Region (28 species from Japan by Okada (1988a) and several species known from Korea and the Soviet Far East), the Oriental Region seems to have a very poor representation of fauna of this subgenus. To date, five named species have been recorded from the Oriental Region (Okada 1977, 1988a; Peng *et al.*

1990; Toda and Peng 1992): both *A. okinawana* Okada and *A. nagatai* Okada from the Ryukyu Islands and Guangdong Province in mainland China, *A. lanceolata* Okada from the Ryukyu Islands, *A. sinuata* Okada from Guangdong Province and Myanmar, and *A. subfurcata* Okada from Japan and Taiwan. Of these, only *A. okinawana* is confined to the Oriental region in its distribution. One unnamed species has been reported from Sri Lanka (Okada 1988b) and Nagaland, India

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(Gupta and Gupta, 1988). In this paper, six species of *Amiota* are recorded from Taiwan, including two previously unreported species. The monotypic subgenus *Apsiphortica* Okada had previously been known only from the holotype specimen of *A. (A.) lini* Okada from Puli, Nantou County, Taiwan; the species quoted here is from a new location. A new subgenus, *Nankangomyia*, has been established for *Leucophenga (Nankangomyia) academica* sp. nov. Its relationship to some other species which were erroneously classified in the subgenus *Phortica* of the genus *Leucophenga* will be discussed. The subgenus *Phortica* will be treated separately.

The morphological terminology used here is based on papers by Okada (1971) and Máca (1980). Wing index values refer to holotype specimens; the range of variability of the wing indices is given in parenthesis. All studied specimens are deposited in the collection of the Institute of Zoology, Academia Sinica, Taipei, Taiwan.

SYSTEMATIC ACCOUNTS

Subgenus *Amiota* s. str.

Amiota Loew, 1862: *Berl. Ent. Z.* 6: 229.

Amiota (s. str.) *okinawana* Okada, 1971

Amiota okinawana Okada, 1971: 86 (type locality: Komi, Iriomote Is., Okinawa, Japan).

Specimen examined: Nankang, Taipei, 27 VIII 1991, 1♂ (Máca), on tree sap of *Citrus* sp.

Distribution: Ryukyu Islands, Guangdong, Taiwan (new record).

Remarks: The specimen differs slightly from the description of the type series by having a lower Ac-index (about 0.5). However, Toda and Peng (1992) show that this index is variable to an extent which is sufficient to support neglecting this difference. The vein

m_{1+2} is very thin and disappears apically, not reaching the wing margin. It may only be an individual monstrosity; this vein is usually thin, but does not disappear apically in the *Amiota* (*Amiota*) species. Aedeagus and anterior paramere are fused, not just closely apposed, contrary to Okada's description (1971, 1988a).

Amiota (s. str.) *furcata* Okada, 1971

Amiota furcata Okada, 1971: 85 (type locality: Kumotoriyama, Tokyo, Japan).

Specimens examined: Sunlinshi, Nantou County, 13 June 1991, 2♂♂; 14 June 1991, 2♂♂ (Máca, Fang, Hong).

Distribution: Japan, Taiwan (new record).

Remarks: Specimens were collected while flying around near to collectors' eyes. The species is readily determined according to the heavy silvery pollinosity of its frons.

Amiota (s. str.) *subfurcata* Okada, 1971

Amiota subfurcata Okada, 1971: 85 (type locality: Sugadaira, Japan).

Specimens examined: Sunlinshi, Nantou County, 14 June 1991, 2♂♂ (Máca, Fang, Hong).

Distribution: Japan, Taiwan. Previously reported from Japan and Taiwan by Okada (1971).

Amiota (s. str.) *dentata* Okada, 1971

Amiota dentata Okada, 1971: 87 (type locality: Hikagezawa, Tokyo).

Specimens examined: Sunlinshi, Nantou County, 13 June 1991, 2♂♂ and 14 June 1991, 1♂ (Máca, Fang, Hong).

Distribution: Japan, Taiwan (new record).

Remarks: Phallic organs are illustrated in this paper (Figs. 1 and 2) to show dentiform projections of the posterior parameres. Only the three caudal pairs of projections were



Figs. 1 and 2. *Amiota dentata* Okada (from Sunlinshi, Taiwan)
 1. Phallic organs, ventral aspect. 2. Lateral aspect. (Scale: 0.05 mm)

illustrated by Okada (1971, 1988a), but according to personal communication from Prof. Okada, the two cranial pairs of projections are also present in the type specimens of *A. dentata*.

Amiota (s. str.) *atomia* sp. nov.
 (Figs. 3-7)

Specimens examined:

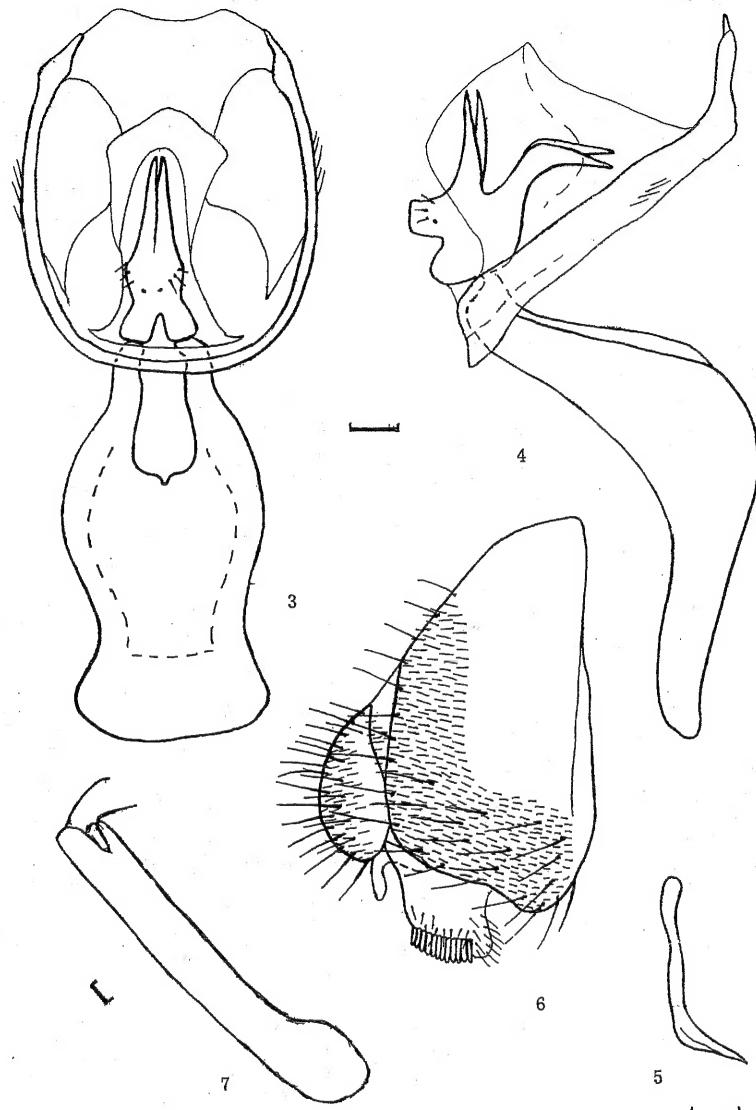
Holotype ♂: Chitou, Nantou County, 1 Oct. 1971 (F. J. Lin and Cheng).

Paratype: 1 ♂, Chitou, Nantou County, 13 Aug. 1971 (F. J. Lin and Wu).

Description:

Male: First two antennal segments brown, 3rd segment dark brown, slightly longer than wide. Arista with 5 upper and 3-5 lower branches; the longest of the lower branches is about 2/3 as long as the longest upper branch. Frons slightly wider than long, very slightly narrowed anteriorly; lower third pale brown with slightly silvery pollinose. Upper part dark brown. About 15-20 scattered tiny frontal bristles, including three on each side in front of orbita (fronto-orbital hairs, Máca, 1980; Fig. 1). Face dark brown with milky white spot below. Palpi brownish black. Gena yellow, postgena dark brown. Width of gena about 1/8 of the greatest diameter of eye.

Mesonotum brownish black. Humeral



Figs. 3-7. *Amiota atomia* sp. nov.
 3. Phallic organs, ventral aspect.
 5. Ejaculatory apodeme.
 7. Femur, 3rd leg. (Scale: 0.05 mm)

4. Lateral aspect.
 6. Periphalllic organs.

spot milky white, with one patch directed medially to this spot and another patch around the mesonotal suture; both are medium to pale brown. Mesonotum with weak pollinosity; scutellum pollinosity heavier. About 12 irregular rows of acrostichals. Anterior dorsocentrals are as long as

prescutellars; posterior dorsocentrals longer. Scutellar bristles subequal in length. Mesopleura and sternopleura dark brown with pale sutures. Pteropleura with milky white spot. Wing length 2.8 mm. Wing indices: C-i ca. 2.4 (2.30-2.42), 4V-i ca. 3.1 (2.76-3.28), 4c-i ca. 1.5 (1.43-1.61), 5x-i ca. 1.1 (1.08-1.20), Ac-

i ca. 3.4 (3.37-4.00), C_3 fringe ca. 0.8 (0.77-0.83). Veins r_{4+5} and m_{1+2} convergent, their apical distance about half of their greatest distance. Legs: Coxae and trochanters brown. Femora darkened (darkening of middle and hind femora more conspicuous). Hind femur with a slight bulbous inflation basally above (Fig. 7). Fore tibia yellowish, middle and hind tibiae dark brown. Preapical bristles found on all three tibiae, with apical bristle on middle tibia. Tarsi yellow. About 30 antero-ventral and equal number of postero-ventral denticles on middle metatarsus, with postero-ventral ones being longer.

First abdominal tergite brown, remaining tergites black. Periphalllic organs (Fig. 5): Epandrium wide, with about 25 bristles scattered along its lower part and 6 bristles at posterior margin. Anal cerci wide. Surstylus setigerous at distal part of outer and inner surfaces, with a slight protuberance directed dorsoanteriorly to a row of 12 primary teeth. Ejaculatory apodeme (Fig. 6) slender. Phallic organs (Figs. 3 and 4): anterior paramere with four sensilla on its basal part, three of them bristle-like. Aedeagus fused to anterior parameres, with paired recurved rods. Posterior paramere large but weakly sclerotized. Apodeme large, dilated medially at the free end. Hypandrium with lateral arms somewhat expanded paramedially, as in *Amiota basdeni* Fonseca.

Amiota (s. str.) *sacculipes* sp. nov.
(Figs. 8-12)

Specimens examined:

Holotype ♂: Sunlinshi, Nantou County, 14 June 1991 (Máca, Fang, Hong).

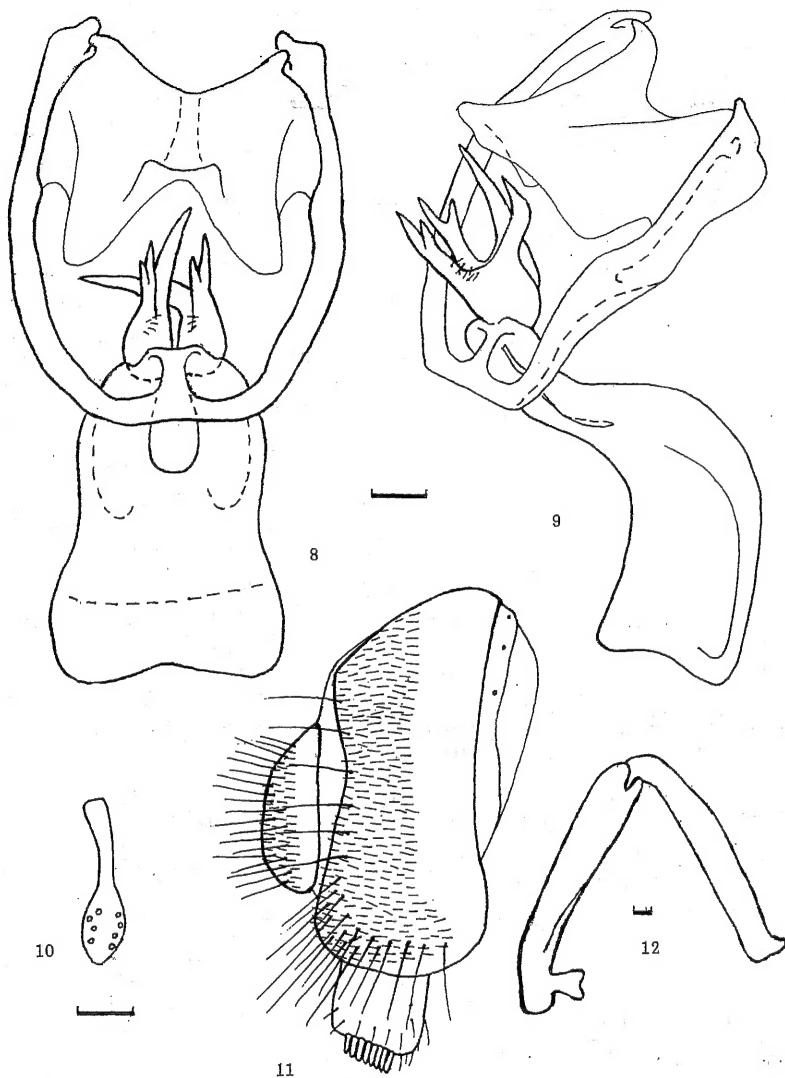
Paratypes: Sunlinshi, Nantou County, 13 June 1991, 2♂♂ and 14 June 1991, 1♂ (Máca, Fang, Hong); Paling, Taoyuan County, 3 July 1991, 1♂ (Máca, Hung, Wong); Wulin, Taichung County, 14 Aug. 1991, 11♂♂ (Máca, Hong, S. F. Lin).

Descriptions:

Male: Antenna brownish black. Arista with 4-5 upper branches and about 7 lower branches, the longest one reaching 1/4 to 1/3 of the length of upper branches. Frons black. Frons width, measured at its anterior margin, equals about half of its medial length; frons width at the level of upper orbital bristles almost equal to the medial length of frons. Face black, with milky white spot below. Palpi medium to dark brown. Gena brown, with its width about 1/10 of the greatest diameter of eye; postgena dark brown.

Mesonotum sub-shining, black, each humeral protuberance with milky white spot. Scutellum somewhat pollinose, black. About 10-12 irregular rows of acrostichals. Dorsocentral and prescutellar bristles as in *Amiota atomia*. Scutellar bristles subequal. Pleural sclerites black, inter-segmental membrane brown. Pteropleura with milky white spot. Wing length 2.1 to 2.5 mm. Wing indices: $C-i$ ca. 1.8 (1.77-2.07), $4V-i$ ca. 2.8 (2.62-2.83), $4c-i$ ca. 1.5 (1.49-1.58), $5x-i$ ca. 1.2 (1.09-1.22), $Ac-i$ ca. 5.2 (4.75-5.28), C_3 fringe ca. 0.8 (0.75-0.84). Veins r_{4+5} and m_{1+2} convergent as in *A. atomia*. Legs: Coxae brown, trochanters pale. Femora dark brown, hind-femur at base paler and with apically widened projection (Fig. 12) which touches the incurved portion of second abdominal tergite in resting position. No specialized bristles on femora. Tibiae yellow, clavate; fore-tibia dorsally at apex with a triangular protuberance. Tibial bristles and tarsi as in *A. atomia*.

Abdominal tergites black. Periphalllic organs (Fig. 10): Epandrium with about 20 bristles in the lower part (confined to the proximity of the lateral margin); 6 bristles at posterior margin. Anal cerci wide. Surstylus with 8 primary teeth and with sparse setae at distal part; no protuberance to primary teeth. Ejaculatory apodeme (Fig. 11) saucer-shaped, with 4 pairs of pits; stalk short. Phallic organs (Figs. 8 and 9): Anterior parameres

Figs. 8-12. *Amiota sacculipes* sp. nov.

8. Phallic organs, ventral aspect.

10. Ejaculatory apodeme.

12. Femur and tibia, 3rd leg.

9. Lateral aspect.

11. Periphalllic organs.

(Scale: 0.05 mm)

apically bifid, fused to aedeagus, this formation is medially divided and asymmetrical. Aedeagal rod on the left part caudally directed, on the right part turned to the left. Posterior paramere roof-like. Aedeagal apodeme medially somewhat narrowed. Hypandrium with a medial projection articulated to the base of anterior parameres.

Key to *Amiota* (s. str.) species of Taiwan

1. Femora darkened at most parts 2
- Legs pale 3
2. Lower branches of arista 2/3 as long as upper branches. Tibiae of mid- and hindlegs dark. Hind femur of male swollen dorsally at base (Fig. 7) *Amiota* (s. str.) *hirsuta* sp. nov.

..... *A. atomia* n. sp.

— Lower branches of arista about 1/3 as long as upper branches. Tibiae yellow. Hind femur of male with apically widened projection at base (Fig. 12)

..... *A. sacculipes* n. sp.

3. Lower branches of arista 2/3 as long as upper branches 4

— Lower branches of arista less than half as long as upper branches 5

4. First abdominal tergite pale, second abdominal tergite pale basally at middle. Ac-index 5.0 to 6.0

..... *A. okinawana* Okada

— All abdominal tergites dark. Ac-index about 4.0 *A. dentata* Okada

5. Frons dark brown, almost parallel-sided below *A. subfurcata* Okada

— Frons silvery pollinose, narrowing below *A. furcata* Okada

Note: Male genitalia should be studied in order to confirm determinations; further species are expected to occur in Taiwan.

Subgenus *Apsiphortica* Okada

Apsiphortica Okada, 1971. *Kontyû* 39: 90.

Amiota (Apsiphortica) lini Okada, 1971

Amiota (Apsiphortica) lini Okada, 1971: 90
(type locality: Puli, Nantou, Taiwan).

Specimens examined: Sunlinshi, Nantou County, 14 June 1991, 3♂♂ (Máca, Fang, Hong).

Distribution: Taiwan.

Remarks: Specimens were collected while flying around human eyes, showing the same behavior as species of the subgenera *Amiota* Loew (s. str.), *Phortica* Schiner, and *Sinophthalmus* Coquillett.

A new subgenus of the genus *Leuco-*

phenga has been established here for a new species plus two species previously assigned to the genus *Amiota*.

Leucophenga subgenus *Nankangomyia*
subg. nov.

Diagnosis: Brief diagnostic characters of the subgenus *Nankangomyia* of the genus *Leucophenga* are listed below:

- (1) Arista with short (Fig. 13) or rather long branches on both sides.
- (2) Frontal hairs coarse.
- (3) Middle orbital bristle close to lower orbital bristle.
- (4) First basal and discal cells of wing clearly separated by cross-vein *bm-cu*.
- (5) Wing veins r_{4+5} and *m* parallel.

Characters 3 and 5 are diagnostic for the genus *Leucophenga*. As for character 1, only long branches of arista occur in *Leucophenga* (s. str.). Characters 2 and 4 are diagnostic for the subgenus *Nankangomyia*. Because of these characters, both previously known species were treated as part of the genus *Amiota* in recent catalogues (Okada 1977; Wheeler 1981); in some species of *Leucophenga* (s. str.), the cross-vein *bm-cu* is weakly foreshadowed, but otherwise it is lacking in this genus (Bächli 1971). *Leucophenga undulata* Hendel, from South America, (the only species of the subgenus *Oxyleucophenga*) has the crossvein *bm-cu*, but no coarse frontal hairs. Some other specific characters were found only in the newly described species and need to be verified for the other two species. These characters are discussed in the remarks section of its description.

Type species: *L. (N.) academica* sp. nov. from Taiwan. The other species tentatively placed in the subgenus are:

L. (N.) parallelinervis (Duda, 1924), comb. nov.; from Java, Indonesia.

= *Phortica parallelinervis* Duda, 1924:

183, 251.

L. (N.) leucophengoides (Sturtevant, 1927), comb. nov.; from Batbatan Is., the Philippines.

= *Amiota leucophengoides* Sturtevant, 1927: 363.

Leucophenga (Nankangomyia) academica

sp. nov.

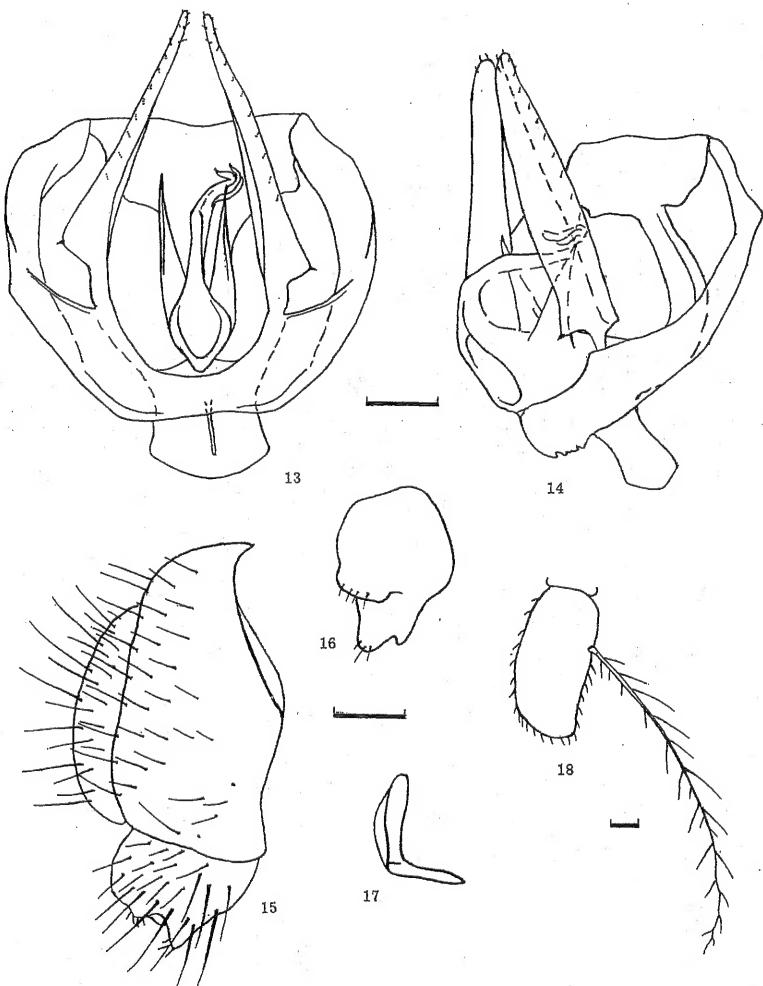
(Figs. 13-18)

Specimen examined:

Holotype ♂: Nankang, Taipei, 12 Oct. 1991 (Máca), from beer trap.

Description:

Male: Antenna pale brown, second segment with approximately 7 bristles, one of them slightly longer (0.06 mm) than the others. Arista 0.60 mm long, with about 10 short branches above and 10 branches



Figs. 13-18. *Leucophenga academica* sp. nov.

- 13. Phallic organs, ventral aspect.
- 15. Periphalllic organs.
- 17. Ejaculatory apodeme.

(Scale: 0.05 mm)

- 14. Lateral aspect.
- 16. Surstyli, caudal aspect (outside bristles omitted).
- 18. 3rd antennal segment (flagellomere 1) and arista.

below, the lower branches being very short at the base of arista and reaching up to 3/4 length of the longest upper branches in the apical half of arista (Fig. 18). Frons yellowish brown below and in the uppermost part, including ocellar triangle and orbits; somewhat darker subdorsally. About 30 coarse frontal hairs or bristles (average length 0.04 mm) in the lower half of frons. Distance between orbital bristles 0.07 mm between lower and middle orbitals, and 0.2 mm between middle and upper orbitals. Between lower and middle orbitals there is a small hair, between middle and upper orbitals a row of 3 (right side) or 4 (left side) hairs, and plus an additional 2 medial hairs. Lower orbital bristles about 0.29 mm long, middle and upper orbitals 0.28 mm. Ocellar bristle 0.31 mm. Postvertical bristles 0.1 mm long, immediately behind them is a pair of bristles of the same length. Additional 8 bristles on the ocellar triangle much shorter. Width of frons 0.33 mm below and 0.45 mm above, length of frons 0.63 mm (all measured on fresh specimen; the frons became shrunken as the specimen dried). Distance between upper orbital and vertical bristles 0.11 mm. Palpi yellow with short bristles. Facial carina well developed, becoming more conspicuous in the dried (shrunken) specimen. Oral bristle short, about 1/3 length of vibrissae.

Mesonotum yellowish brown, acrostichals arranged in approximately 18 irregular rows. Length of anterior and posterior dorsocentral bristles 0.23 mm and 0.65 mm, respectively. The apex of anterior dorsocentrals extends slightly beyond the base of posterior dorsocentrals. Length of primary prescutellar bristles 0.40 mm, with secondary prescutellar bristles (elongated bristles directed laterally to prescutellars) measured at 0.15 mm (semilateral pair) and 0.23 to 0.25 mm (lateral pair). Distance between anterior and posterior dorsocentrals smaller than the distance between posterior dorsocentrals and primary prescutellars. Scutellar bristles about

0.45 mm long and subequal. One humeral bristle as long as the presutural bristle and second notopleural bristle (0.30 mm); first notopleural bristle longer (0.43 mm). Three supraalar bristles 0.25, 0.63 and 0.55 mm long; first supraalar bristle in more dorsal position than the other two. Anterior sternopleural bristle 0.38 mm, posterior sternopleural bristle 0.50 mm; sterno-index 0.76. A group of 4 small bristles between them, with a vertical row of 7 small bristles directed ventrally to the anterior sternopleural. Wing slightly cloudy subapically at the anterior part; this darkening reaches r_{4+5} vein. Costal vein reaches slightly behind the r_{4+5} . No costal warts. First basal cell separated from the discal cell by a cross-vein. Angle between tp and middle section of m_{3+4} about 60°. Wing indices: C-i 2.5, 4V-i 1.63, 4c-i 0.93, 5x-i 0.91, Ac-i 2.73, and C_3 fringe 0.69. Wing length 3.10 mm. Veins yellow to brown, r_3 slightly sinuate, r_{4+5} slightly bent backward and parallel to m_1 . Halteres yellowish. Legs yellow. First coxa with 4 stout bristles, 2nd coxa also with 4 bristles (in an irregular transverse row), and 3rd coxa with 2 bristles. First femur with 4 bristles in latero-dorsal position. Preapical bristles on all three tibiae; apical bristle only on mid-tibia. Ratio of tibiae length to tarsi length (1st to 3rd legs): 0.71, 0.64, and 1.00, respectively. Middle metatarsus has posteroventral row of about 20 small and only slightly modified bristles.

Abdominal tergites (1 to 2) yellow, and following tergites dark brown; incurved portions of tergites (3 to 5) yellow, with tergites 3 and 4 showing whitish yellow apical bands. Sternites with numerous setae; 5th sternite with about 60 setae. Periphalllic organs (Figs. 15 and 16): Epandrium dilated medially, with microtrichiae over virtually the entire surface (microtrichiae not shown in Fig. 15). Anal lamella large with 3 irregular vertical rows of bristles. Surstyli trilobed, medial lobe projecting into blunt tooth. Ejaculatory apodeme (Fig. 17) small with somewhat dilated stalk.

Phallic organs (Figs. 13 and 14): Anterior paramere with a dorsal row of 14 sensilla and one small thorn ventrally at base. Aedeagus with medial rod curved backwards, genital orifice shifted to the base of aedeagus. Aedeagal apodeme wide, short, and dorso-ventrally flattened. Posterior paramere more widen and flat above. Medial part of hypandrium membranous except for its anterior margin.

Remarks: This species has a number of specific characters which may or may not be common to members of the subgenus *Nankangomyia*: 1) anterior dorsocentrals are considerably shorter than primary prescutellars, 2) posterior cross-vein is oblique, 3) postero-ventral bristles of middle metatarsus are almost unmodified, 4) abdominal sternites have numerous setae, 5) posterior paramere is flat above, 6) aedeagal apodeme is dorso-ventrally flattened, 7) aedeagus with its genital orifice shifted basally, and 8) a trilobed surstyli. Some of these characters — e.g., 1, 2, and 3 — resemble the genus *Cacoxenus*. Even the short aristal branches in two of the three species of the subgenus (*L. academica* and *L. parallelinervis*) are intermediate between *Leucophenga* and *Cacoxenus*. The two above species also have in common a reduced number of outstanding latero-dorsal bristles on the first femur (4 and 2 bristles, respectively; nothing is known about these bristles in *L. leucophengoides*). A shortening of the costal vein up to the apex of r_{4+5} (a key character of the genus *Leucophenga*) is developed in *L. academica* and *L. leucophengoides*, but not in *L. parallelinervis*. Some characters of *L. academica* (mainly character 7) resemble the genus *Amiota*. However, by disregarding different conclusions concerning recent taxonomic treatments of Drosophilidae both Okada (1989) and Grimaldi (1990) placed the genus *Leucophenga* quite apart from *Cacoxenus* and *Amiota* — in fact, in a separate tribe (Leucophengini, and Steganini). The trilob-

ed surstyli is also developed in some species in the genus *Paraleucophenga* which were treated by Okada; however, *Paraleucophenga* species possess a row of prensisetae on the surstyli, and the arrangement of sterno-pleural bristles is different. According to the sparse information available, members of the nominal genus *Erima* differ from *Leucophenga* (s. lat.) by bare arista, furate anterior paramers etc. (Tsacas 1983). Further information about *L. leucophengoides* and *L. parallelinervis* is needed; this information may contribute to the clarification of taxonomic relationships within the subfamily Steganinae.

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臺灣的果蠅科昆蟲：繞眼果蠅屬(不含眼高果蠅亞屬) 及白果蠅屬(南港白果蠅亞屬)新亞屬

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本文記載臺灣產 6 種繞眼果蠅屬 (genus *Amiota*) 繞眼果蠅亞屬 (subg. *Amiota*) 之果蠅，分別為 *Amiota* (*Amiota*) *furcata* Okada (長齒繞眼果蠅)、*A.* (*A.*) *subfurcata* Okada (短齒繞眼果蠅)、*A.* (*A.*) *dentata* Okada (鋸齒繞眼果蠅)、*A.* (*A.*) *okinawana* Okada (沖繩繞眼果蠅)、*A.* (*A.*) *atomia* n. sp. (原核繞眼果蠅) 及 *A.* (*A.*) *sacculipes* n. sp. (小袋繞眼果蠅)。擬眼高繞眼果蠅亞屬 (subg. *Apsiphortica*) 目前只記載一種 *Amiota* (*Apsiphortica*) *lini* (林氏繞眼果蠅) 也在新的產地採到。本文並新列屬於白果蠅屬 (genus *Leucophenga*) 中之南港白果蠅亞屬 (subg. *Nankangomyia*) 為新亞屬；包括下列 3 種：學院白果蠅 (*L.* (*N.*) *academica* n.sp.)、產於爪哇之平行脈白果蠅 (*L.* (*N.*) *parallel nervis* (Duda, 1924))、及產於菲律賓之擬白果蠅 (*L.* (*N.*) *leucophengoides* (Sturtevant, 1927))。文中並討論南港白果蠅亞屬新亞屬建立之理論根據。

Histochemical studies on normal and *Bacillus thuringiensis*-infected *Pieris canidia* larval midgut

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Wilkin Wai-Kuen Cheung and Yui-Fong Lam (1993). Histochemical studies on normal and *Bacillus thuringiensis*-infected *Pieris canidia* larval midgut. *Bull. Inst. Zool., Academia Sinica* 32(1): 12-22. Histochemical changes in the midgut of *Pieris canidia* were investigated after infection with *Bacillus thuringiensis* var. *kurstaki* (Btk) at various time intervals. Results showed that epithelial cell (both columnar and goblet cells) microvilli, together with the contents of the goblet cavity of goblet cells, reacted strongly positive to a PAS test; however, those in infected larvae showed a weaker PAS-positive reaction. The goblet cells appeared to be damaged more slowly than the columnar cells. Alcian Blue and Toluidine Blue staining produced negative results for both normal and Btk-infected midguts, but tests for proteins produced strongly positive results for both types of midgut. Tests for lipids showed that normal epithelial cells contained large lipid droplets while Btk-treated midguts did not. Alkaline phosphatase was localized on the microvilli of normal epithelial cells, but disappeared after four hours of bacterial treatment. Our results are discussed with reference to the ultrastructural aspects of damage which were reported on in an earlier paper.

Key words: *Pieris*, Insect midgut, *Bacillus thuringiensis*, Histochemistry, Histopathology.

The microbial insecticide *Bacillus thuringiensis* var. *kurstaki* (Btk) is presently a popular biocontrolling agent for lepidopterous larvae, and has been recently introduced to Hong Kong for controlling small cabbage white *Pieris canidia* and related lepidopterous larvae. It has the advantage of being easily and cheaply produced, as well as being specific to the target pest and non-toxic to the general environment (see reviews by Faust and Bulla, 1982; Kirschbaum, 1985; and Whiteley and Schnept, 1986).

The histopathology of lepidopterous larvae infected with *Bacillus thuringiensis* (Bt) has been well documented. Sutter and Raun (1967) found that Bt vegetative rods penetrated the midgut epithelium of the corn

borer *Ostrinia*, causing damage to that insect's basement membrane. Endo and Nishiitsutsuji-Uwo (1980) reported different types of damage done by the Bt toxin to the columnar and goblet cells of the silkworm *Bombyx*. Delello *et al.* (1984) found that, even at very low doses, Bt endotoxins damaged the rough endoplasmic reticulum and mitochondria of the tobacco hornworm *Manduca*. Chiang *et al.* (1986) described the defense reaction to Bt of midgut epithelial cells in the rice borer *Corcyra*, and Cheung *et al.* (1990) found that goblet cells in the small cabbage white *Pieris canidia* experienced slower damage than columnar cells when a Bt spore-toxin mixture was ingested by larvae. This insect's midgut epithelial cells showed that their microvilli, endoplasmic